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UNITED STATES PATENT APPLICATION

OF

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FOR

COIL GASKET

TITLE OF THE INVENTION

Coil Gasket

BACKGROUND OF THE INVENTION

A wide variety of gaskets are known for use in sealing applications. Porous expanded polytetrafluoroethylene (PTFE) is widely used today as a gasket material. As disclosed in U.S. Patent No. 3,953,566 to Gore, this material has numerous properties making it highly desirable as a gasket. These properties include being readily compressible and conformable, being chemically resistant, having relatively high strength, and being far less prone to creep relaxation and loss of sealing pressure than non-expanded, non-porous PTFE alone.

Furthermore, gaskets made from biaxially or multiaxially expanded PTFE have improved sealing performance as compared to uniaxially expanded PTFE gaskets. For example, gaskets made from multiaxially expanded PTFE are resistant to creep relaxation and cold flow in multiple directions. The multi-directional tensile strength in multiaxially expanded PTFE gaskets provides circumferential and radial strength to the gasket and increases the cut through resistance of the gasket. Enhanced radial strength and cut through resistance provided by multiaxially expanded PTFE is achieved when the plane of expansion of the expanded PTFE is substantially parallel to the flange surface on which the gasket is installed.

In many sealing applications, the gasket is used to seal the junction between flanges, such as between pipes. Expanded PTFE is a desirable material for the gaskets because the expanded PTFE gasket can be placed between the flanges, and the flanges can then be pressed together with the application of force, such as by tightening of bolts. This application of force compresses the expanded PTFE. As the expanded PTFE is compressed, its initial pore volume is reduced, thus densifying the expanded PTFE. Particularly with metal-to-metal flanges, it is possible to apply sufficient force (or “stress”) to the flanges to fully densify the expanded PTFE. Thus, in at least part of the expanded PTFE

gasket, the pore volume may be reduced to substantially zero, preventing fluid contained within the pipes from leaking between the flanges by the densified, non-porous PTFE gasket, which seals the flanges.

In many applications, particularly when harsh chemicals are used which would readily break down the metal or the metal could contaminate the chemical which is being transported or housed, it is common to use glass-lined steel, glass, or fiberglass reinforced plastic ("FRP") piping and vessels. Because this equipment is often used with extremely harsh chemicals, there is a great desire to use PTFE gaskets to seal the connecting flanges of this equipment because of the well-known extraordinary chemical resistance of PTFE. Unfortunately, non-expanded, non-porous PTFE gaskets are generally not conformable enough to effectively seal this type of equipment. In the case of glass-lined steel flanges, although there is a relatively smooth finish, there is often a large amount of unevenness or lack of flatness associated with the flanges. This unevenness or lack of flatness requires the gasket to conform to large variations around the perimeter as well as between the internal and external diameter of the flange in order for an effective seal to be created. Thus, a non-expanded, non-porous PTFE gasket is not conformable enough to provide an adequate seal in many of these applications.

Because expanded PTFE is conformable, it would be desirable to use expanded PTFE to seal these commonly uneven flanges. Unfortunately, in many applications it is not possible to apply sufficient force to the flanges to create enough gasket stress to fully densify the expanded PTFE gasket to create an effective seal. For example, glass-lined steel piping flanges, glass flanges, or FRP piping flanges may deform, fracture, or break upon the application of a high amount of stress. Thus, in these applications, an expanded PTFE gasket may not be completely densified to reach a non-porous state, and therefore does not become leak proof, because the maximum stress that can be applied to the flanges without breaking them is not sufficient to densify the gasket. In some constructions where expanded PTFE gasket is not densified to a substantially non-porous state, leakage can occur through the residual porosity within the gasket. Often, this leakage is detected immediately after the installation of the gasket through either a "sniffing" technique or a "bubble test". In the bubble

test, a solution such as soapy water is applied to the gasketed flange and an internal air pressure is applied to the piping system or vessel. If a leak of a sufficient rate is present, bubbles will form in the soapy water solution. In some cases, a leak may exist but at a rate small enough not to form a bubble. In such cases and where corrosive chemicals are being processed, the leak may persist for months or years where the corrosive chemicals can eventually leak through the gasket undetected and attack the flange bolts or clamps resulting in a catastrophic failure of the flange.

As discussed in U.S. Patent Publication 2003/0003290 in the name of Hisano et al., methods are known in industry for producing gaskets by wrapping ePTFE films on a mandrel to produce a tubular element whereby the tubular element is sliced into rings to produce gaskets. Within the laminated layers of these gaskets, a compact ePTFE film is interposed to prevent fluid penetration leakage through the gasket. These methods for producing such gaskets are limited in the size of gaskets that can be produced. The laminate thickness in these methods is typically limited to a maximum of about 10 mm to 15 mm which corresponds to the a gasket width of only 15 mm or less. Laminate thicknesses greater than this are difficult to restrain during the sintering process and can result in significant density gradients within the laminate. Gasket widths in typical applications, especially with larger diameter gaskets, are generally on the order of 25 mm and greater. Furthermore, when the tubular element is sliced, the laminate layers of the ePTFE are oriented perpendicular to the gasket upper and lower surfaces. Therefore, the transverse direction of expansion of the ePTFE is oriented in the z direction or thickness direction of the gasket and provides little or no strength to the gasket in the radial direction.

U. S. Patent No. 6,485,809, in the name of Minor et al., teaches a low stress to seal gasket construction comprising a multilayer, unitary gasket including at least one inner layer of expanded PTFE disposed between a first substantially air impermeable outer layer and a second substantially air impermeable outer layer, and a substantially air impermeable region bridging the first and second substantially air impermeable layers. By "low stress to seal" is meant a gasket which provides a substantially air tight, or air impermeable, seal upon the application of a relatively low stress (i.e., a stress

below that required to fully densify a porous expanded PTFE gasket, generally less than about 20,700 kPa (3000 psi)). This patent teaches gaskets which are stamped or cut from multilayered laminated sheets formed by wrapping layers around a mandrel, and subjecting gaskets to compressive treatment to compress a discreet portion and form an air impermeable region. While this patented construction may overcome many challenges in creating a low stress to seal gasket, there are limitations to the sizes of gaskets that can be produced when cutting gaskets from sheet goods. The largest size gasket that can be produced when cutting from sheet gasketing cannot be larger than the sheet size itself. Another concern with the manufacturing of such large size gaskets from sheet gasketing materials is the cost associated with producing such gaskets. For example, the manufacturing efficiencies of cutting gaskets from sheet stock can be relatively low especially with large diameter gaskets..

U. S. Patent No. 4,990,296 to Pitolaj teaches a method of welding together filled sintered PTFE components, wherein large diameter gaskets can be formed in sections by welding the ends of the sections together. This method, while perhaps suitable for sintered filled PTFE, would not be suitable for soft, porous expanded PTFE which would densify as a result of the applied heat and pressure at the welded joint. Densification would result in thinner, hard and non-conformable sections within the gasket. A gasket having variable thickness and softness would not be able to effectively seal fragile flanges such as glass lined steel and FRP flanges.

U. S. Patent No. 5,964,465 to Mills et al. teaches a biaxially expanded PTFE form-in-place type gasket. Form-in-place gaskets have the advantage of being able to be formed to any size flange without the limitations of gaskets cut from sheet stock such as low material utilization rates. Form-in-place gaskets made in accordance with the teachings of Mills et al., comprised of biaxially expanded PTFE, may have additional advantages offered by the biaxially expanded PTFE such as chemical resistance, dimensional stability, and resistance to creep relaxation. However, as previously noted, since adequate gasket stress cannot be applied to densify the ePTFE, these gaskets cannot effectively seal glass lined steel and FRP flanges.

In PCT publication WO01/27501 A1 to Dove et al., a form-in-place gasket comprising an inner layer of expanded PTFE and substantially air impermeable outer layers that are bridged by a substantially impermeable region is taught. The substantially air impermeable outer layers and substantially air impermeable region are intended to prevent permeation through the expanded PTFE gasket material. The purpose of this gasket construction is to provide a tight seal at the low stresses where ePTFE alone can not be fully densified by preventing leakage through the porous ePTFE. However, gaskets constructed according to the teachings of WO 01/27501 are subject to a number of disadvantages. For example, outer air impermeable layers made of incompressible materials such as full density PTFE or densified expanded PTFE may increase the stiffness of the gasket, making it too rigid for a form-in-place gasket. It is desirable for form-in-place gaskets to be flexible so that they can be formed to the geometry of the flange.

Further, form-in-place gaskets comprising biaxially expanded PTFE are typically joined at the ends by skive-cutting the ends and overlapping the skive cut ends as taught in U.S. Patent No. 5,964,465. Form-in-place gaskets constructed in accordance with PCT publication WO01/27501 A1 to Dove et al. having the outer impermeable layers, cannot be joined by overlapping the ends of the tape using the skive cutting technique without compromising the air impermeable nature of the material. When a skive cut is made through the outer air impermeable layers, porous expanded PTFE may be exposed, providing a leak path through the gasket.

In U.S. Patent Publication No. 2003/0003290 A1 to Hisano et al., a sealing material in the form of a tape is taught which consists of laminated layers of porous expanded PTFE which are slit into strips having a height greater than the width, and wherein the laminated end faces on the long side of the laminated strip are in contact with the tightening surface. A plurality of the laminated strips may be joined together on the laminated surfaces of the laminate with tetrafluoroethylene-hexafluoropropylene copolymer or tetrafluoroethylene-perfluoroalkyl vinyl ether copolymer film. It is further taught that at least one layer may be interposed within the laminate for preventing fluid penetration. In the form of a closed ring or gasket where the

longitudinal beginning and end of the tape has been joined, the layers of expanded PTFE and the layer for preventing fluid penetration are vertically oriented when the gasket is installed on a flange surface. The layers intended to prevent fluid penetration in the radial direction may provide the gasket with low stress to seal capability by preventing leakage through the porous ePTFE. For gaskets made according to this method, the longitudinal strength of the expanded PTFE provides strength to the gasket in the circumferential direction when the gasket is installed on a flange surface. However, with the ePTFE layers laminated in the width direction, the transverse directional strength of the ePTFE is oriented in the vertical or "z" direction of the gasket. Therefore, little to no strength is provided to the gasket in the radial direction. Therefore, gaskets taught in U.S. Patent Publication No. 2003/0003290 A1 would be prone to cold flow in the width direction and lack dimensional stability. For gasketing applications involving glass lined steel flanges it is preferred that the gasket material to be dimensionally stable to prevent fracture of the glass lining.

Form-in-place gaskets, especially biaxially expanded PTFE gaskets, have the disadvantage of requiring an overlap of the ends of the tape to form the closed shape of a gasket. It is usually necessary for skilled operators to perform the installation of these gaskets in order to insure the skive cut is done correctly. Improper installation may result in leakage at the overlap site. In many applications form-in-place gaskets are not deemed acceptable because of the overlapped ends which is perceived as a weak point within the gasket. Because of this concern there is reluctance to using biaxially expanded PTFE form-in-place gaskets.

It would be desirable to provide a gasket that can be formed from a tape to avoid the low yields and high costs associated with cutting gaskets from sheet stocks and that would also not be limited in size or shape. It would also be desirable for such a gasket to be a continuous and unitary gasket without joints resulting from overlapping tape ends. It would be further desirable for such a gasket to be a conformable, creep resistant, and chemically resistant gasket that can seal at the low stresses common to applications in which glass lined steel and FRP flanges are used, and that does not fracture upon the application of high compressive stresses commonly used to seal steel flanges. It is therefore one

object of the present invention to provide a continuous, unitary gasket made from an expanded PTFE tape that provides a substantially air tight seal upon the application of low stress and to provide a method for manufacturing such a gasket.

SUMMARY OF THE INVENTION

The present invention provides a unitary structure, such as a gasket, formed from winding at least one length of ePTFE tape and joining the tape windings. Interposed between the windings of the tape is a substantially air impermeable layer. Where a gasket is formed, the substantially air impermeable layer prevents penetration or leakage through the gasket in the radial direction. Gaskets of the present invention had significantly lower leak rates than traditional sheet or tape gaskets when tested for sealability. A decrease in leak rate of about 1.5 orders of magnitude or more was realized with the inventive gaskets having a substantially air impermeable layer as compared with gaskets cut from ePTFE sheet and formed from ePTFE tape without any impermeable layers interposed therein. The lower leak rate demonstrated by the gaskets of the present invention is attributable in part to the substantially parallel orientation of the plane of expansion of the expanded PTFE with the flange surface and the incorporation of substantially air impermeable layers interposed within the gasket.

In another aspect, the invention provides a method for producing a gasket comprising the steps of providing an ePTFE tape and a material capable of forming a substantially air impermeable layer, winding the ePTFE tape and the substantially air impermeable layer, to form alternating windings of ePTFE and the substantially air impermeable layer, and joining the windings.

BRIEF DESCRIPTION OF THE DRAWINGS

A fuller understanding of the present invention will be gained by reference to the following detailed description when read in conjunction with accompanying drawings. It should be understood that the invention is not limited to the precise arrangement shown.

Fig. 1 is a top view and cross-section views of a gasket in accordance with the present invention.

Fig. 2 is a top view of a gasket in accordance with the present invention.

Fig. 3 is a top view of a gasket in accordance with the present invention.

Fig. 4 is a three-quarter perspective view of a form-in-place gasket.

Fig. 5 is a three-quarter perspective view of a tape material and orientation.

Fig. 6 is an exploded view of a fixture and a method of assembling a tape having a barrier layer.

Fig. 7 is a side view of a fixture and method of assembling a gasket in accordance with the present invention.

Fig. 8 is a graphical representation of leak rate results of gaskets at a gasket stress of about 6 MPa

Fig. 9 is a side cross-sectional view of a test apparatus used to measure sealability of gaskets.

Fig. 10 is a three-quarter perspective view of a gasket tape and orientation.

Fig. 11 is a graphical representation of Wide-Angle X-ray Scattering Test results.

DETAILED DESCRIPTION OF THE INVENTION

The preferred embodiment of the present invention is directed to a gasket that provides a substantially air impermeable seal with low load upon the tightening surfaces, and with low stress applied to the gaskets. In one preferred embodiment, a gasket is formed comprising alternate windings of a tape comprising ePTFE and a substantially air impermeable layer, each winding at an increasing distance around the inner diameter or inner periphery of a gasket. Gaskets of the present invention exhibit excellent dimensional stability and resistance to creep relaxation. The present invention is further directed to novel methods for forming the novel structures of the present invention. Methods are disclosed for joining or bonding together windings of ePTFE tape, such as multilayered porous expanded PTFE tapes, with a substantially air impermeable layer between the tape windings. The novel methods provide low stress to seal gaskets, and are particularly useful for large size gaskets.

As previously stated, by "low stress to seal gasket" is meant a gasket, such as a gasket of the present invention, which provides a substantially air tight, or air impermeable, seal upon the application of a relatively low stress (i.e., a stress below that required to fully densify a porous expanded

polytetrafluoroethylene (ePTFE) gasket, generally less than about 20,700 kPa (3000 psi)).

By "air impermeable" as used herein is meant resistant to the transport of air through a material. Permeability may be measured using any known technique, such as ASTM D-1434-82 (2003).

Exemplary embodiments of the present invention are illustrated in Figs. 1-3. Figs. 1-3 illustrate preferred unitary gaskets each comprising an inner periphery or diameter 9 and at least two windings or rotations of at least one porous expanded PTFE tape 10. The windings of the ePTFE tape are alternated with windings of at least one substantially air impermeable layer 11 also wound in an increasing distance around the inner periphery or diameter. Preferably, each winding or rotation of the at least one expanded PTFE tape 10 is alternated and joined by the at least one substantially air impermeable layer 11.

Illustrated in Figs. 1a and 1b are cross-sections of a representative gasket of the present invention. The expanded PTFE tape has upper and lower tape surfaces 16 corresponding to upper and lower gasket surfaces, and side surfaces 18 extending between the upper and lower tapes surfaces. Preferably, as shown in Figs. 1a and 1b, the substantially air impermeable layer 11 is bonded to side surfaces 18 of multi-layered porous ePTFE tape, the side surfaces extending between upper and lower laminate tape layers.

Gaskets of the present invention may be formed from one tape or a plurality of tapes, and is not particularly limited by the number of tapes that may be joined to form the gasket. For example, more than one tape may be wound simultaneously around a form to form tape windings. The at least one tape making up the gasket may be monolithic or multilayered porous expanded PTFE. Preferred porous ePTFE tapes suitable for use in the present invention are multilayered laminate tape wherein the plane of expansion of the ePTFE is in the x-y plane of the tape, and the ePTFE layers including upper and lower tape layers of the tape are parallel to the plane of expansion. Fig. 5 illustrates a multilayer tape suitable for use in the present invention having upper and lower tape layers (56) in the X-Y plan of the tape. Where the ePTFE tape is monolithic, it is preferred that the plane of expansion of the ePTFE is parallel to the x-y plane of the tape. Preferably, the x-y plane of the tape is substantially

parallel to the sealing surface. The plane of expansion of ePTFE can be determined, for example, by Wide-Angle X-ray Scattering test methods, as described herein.

Preferred porous expanded PTFE comprises microporous expanded PTFE as taught in U.S. Pat. Nos. 3,953,566 and 4,187,390, incorporated herein by reference. PTFE may be expanded uniaxially, biaxially, or multiaxially, and preferably has a density of less than 1.8 g/cc, more preferred less than 1.2 g/cc, further preferred less than 1.0 g/cc, and a most preferred density of less than 0.8 g/cc. While not limited by a number of porous expanded PTFE layers, preferred multilayered tape is formed from multiple self-adhered porous expanded PTFE layers, made by any method known in the art for forming multilayered porous expanded PTFE tapes; methods suitable for use in the present invention are described, for example, in U.S. Pat. No. 5,964,465, and 6,485,809 which are hereby incorporated herein by reference. Suitable tape is commercially available, for example, under the trade names GORE-TEX® Gasket Tape, GORE-TEX® Series 300 Gasket Tape and GORE-TEX® Series 600 Gasket Tape (W.L. Gore & Assoc., Inc., Elkton, MD).

While preferably all layers of multilayer ePTFE tape are ePTFE, alternately, one or more tape layers may comprise materials other than a PTFE material to provide desired properties to the gasket. For example, one or more of polymeric films, metal foils, metal screens or the like may be provided to the multilayered tape to enhance properties to the resulting gasket. In a preferred embodiment a gasket is formed from at least one multilayered laminated ePTFE tape in which upper and lower laminate layers are ePTFE.

At least a portion of the porous expanded PTFE, or at least one layer of multilayered PTFE tape, may be coated or filled to provide desired properties to the gasket. For example, expanded PTFE may be coated to provide properties such as resilience, electrochemical responsiveness, added strength, further reduced creep relaxation, and the like. Additionally, porous expanded PTFE may be filled with various fillers, for example, such as those used to fill expanded microporous PTFE sheets as taught in U.S. Pat. Nos. 4,096,227 and 4,985,296, incorporated herein by reference. Suitable particulate fillers may include, for example, inorganic materials such as metals, semi-metals, metal

oxides, glass, ceramic and the like. Alternatively, other suitable particulate fillers may include, for example, organic materials selected from activated carbon, carbon black, polymeric resin, graphite and the like. In one preferred embodiment at least one layer of multilayered porous expanded PTFE tape comprises at least one filler. Preferably, the at least one filler comprises at least one of silica, barium sulfate and glass beads.

At least one substantially air impermeable layer is alternately wound with at least one porous ePTFE tape for at least two windings of the ePTFE tape at an increasing distance around a center point such as a gasket inner periphery. The substantially air impermeable layer may be bonded to the ePTFE tape prior to tape winding or during the winding process. Substantially air impermeable layers prevent fluid from permeating through the gaskets in the radial direction providing the low stress to seal nature of the gasket. Substantially air impermeable materials of the present invention are more air impermeable than the porous expanded PTFE materials used to form the tape. Materials suitable for use in the present invention comprise an air impermeable material, or at least one material capable of forming an air impermeable layer having a permeability to air that is less than the porous expanded PTFE of the tape material. Preferred air impermeable materials comprise fluoropolymers, including, but not limited to, tetrafluoroethylene/ hexafluoropropylene copolymer (FEP), tetrafluoroethylene/ (perfluoroalkyl) vinyl ether copolymer (PFA), PTFE, densified expanded PTFE, and combinations thereof. Preferred are melt processable fluoropolymers. Most preferred are PFA and FEP. Air impermeable material may comprise porous PTFE impregnated with fillers such as an elastomer, a fluoroelastomer, a perfluoroelastomer, or a perfluorosilicone elastomer. Preferred are air impermeable layers having a width of about 0.01 mm to 0.5 mm when calculated, for example, by measuring the distance between two ePTFE tape windings that are aligned along side surfaces and joined by the substantially air impermeable layer.

Gaskets of the present invention are preferably formed from at least one porous ePTFE tape wound around the outer periphery of a form or die at an increasing distance from the form or die until at least two turns around the form are achieved. It is preferred that the ePTFE is wound continuously for at least

two windings or rotations around the form or die at increasing distances from the outer periphery to form a coil. At least two sequential or adjacent ePTFE windings are preferably joined by interposing alternating windings of at least one substantially air impermeable material between the ePTFE windings. The at least two windings of at least one ePTFE tape and at least one substantially air impermeable material are joined to form a unitary gasket. The shape of the die and gasket is not limited and therefore may be formed into any desired shape, such as circular or non-circular, including but not limited to a substantially circular, elliptical, rectangular or square shape. Thus, the term "coil" as used herein refers to any shape formed from multiple rotations or windings of at least one ePTFE tape at an increasing distance around a center point, an inner gasket periphery, or an outer periphery of a die or form. Each rotation of the ePTFE tape winding is aligned along the length of adjacent ePTFE tape windings at an increasing distance from the die or the inner diameter/periphery of the gasket. Preferably, the tape windings are aligned along tape side surfaces, and at least one air impermeable layer extends between the tape side surfaces to join each winding of ePTFE of the tape to form a unitary gasket. A preferred gasket, such as a circular gasket, comprises an inner diameter and at least two spirals comprising alternating rotations of at least one porous multilayer ePTFE tape and at least one substantially air impermeable layer. The spirals of ePTFE tape and the substantially air impermeable layer preferably rotate in an increasing distance around the inner diameter for at least two rotations of the ePTFE. The preferred ePTFE tape is a multilayer tape having upper and lower tape layers, and side surfaces extend between upper and lower tape layers. The rotations of ePTFE tape are aligned along tape side surfaces and joined at the side surfaces by the alternating spiral of at least one substantially air impermeable layer between the rotations of ePTFE.

Where the tape comprises a plurality of laminated layers, the tape side surface is defined by the laminated edge (e.g., Fig. 5, at 58) which extends between upper and lower tape layers (Fig. 5, 56). Multiple tape windings are aligned along tape side surfaces and the at least one substantially air impermeable layer is positioned on the laminated edge between the adjacent ePTFE tape side surfaces. The substantially air impermeable layer extends from

the upper tape layers to the lower tape layers of the tape. Preferably, the air impermeable layer extends substantially completely between the upper and lower tape layers, e.g. generally in the x-z plane of the tape, for the entire length of the wound tape. Preferred gaskets comprise multilayered porous multiaxially expanded PTFE tape having upper and lower laminate tape layers in the x-y plane of the tape, that define upper and lower gasket surfaces. Where gasket comprises monolithic porous ePTFE tape, upper and lower tape surfaces in the x-y plane of the tape correspond to, or define the upper and lower gasket surfaces. It is preferred that alternating windings of at least one ePTFE tape and at least one substantially air impermeable layer are wound so that the plane of expansion of the ePTFE tape is in the x-y plane of the tape. It is preferred that the plane of expansion is oriented substantially parallel to upper and lower gasket surfaces of an uncompressed gasket providing strength in at least both the circumferential and radial directions.

As illustrated in Fig. 1a and 1b, where tape side surfaces are perpendicular to the upper and lower gasket surfaces, the air impermeable layer joined thereto extends substantially along the x-z plane of the tape preventing the flow of liquid in the radial direction through the gasket. The length of the tape forming the windings of the inventive gasket prevents leakage through the longitudinal direction of the tape. Preferred gaskets of the present invention have a substantially uniform thickness across the width of an uncompressed gasket. Therefore, uncompressed gaskets of the present invention preferably have a uniform thickness across the upper and lower gasket surfaces between inner and outer gasket diameters.

The novel gaskets of the present invention are preferably formed from the following novel methods.

A process is provided comprising the steps of providing a length of at least one porous ePTFE tape having upper and lower tape layers or surfaces, and side surfaces extending between upper and lower tape layers or surfaces, and providing at least one material capable of forming a substantially air impermeable layer. The method further comprises coiling the at least one ePTFE tape and the at least one material capable of forming a substantially air impermeable material, forming alternating windings of the ePTFE tape and the

at least one material capable of forming a substantially air impermeable layer at increasing distances around a center point, and joining the alternating windings to form a unitary structure of the at least one ePTFE tape and the at least one substantially air impermeable layer.

In one preferred embodiment, the at least one ePTFE tape and at least one substantially air impermeable layer are coiled or wound around a form defining the inner periphery of a gasket, such as a die, forming alternating windings. Tape is aligned along the tape side surfaces with the at least one substantially air impermeable layer interposed between the ePTFE tape windings. The at least one ePTFE tape is preferably aligned wherein upper and lower tape layers or surfaces, and the plane of expansion of the ePTFE, are both in the x-y plane of the gasket. The method further comprises joining the windings of the at least one ePTFE tape and the at least one substantially air impermeable layer along tape side surfaces. A unitary gasket is formed comprising at least two windings of at least one ePTFE tape around an inner periphery, each ePTFE winding alternated with at least one substantially air impermeable material. In a preferred embodiment, at least one substantially air impermeable layer is first formed or bonded on the two side surfaces of at least one porous ePTFE tape prior to winding at least one ePTFE tape to form a gasket. A method for forming or bonding the substantially air impermeable layer on the ePTFE tape side surfaces comprises the steps of providing a length of tape having upper and lower surfaces or layers and tape side surfaces extending the length of the tape between upper and lower surfaces or layers; providing a material capable of forming a substantially air impermeable layer; aligning the material along the length of the ePTFE tape on the tape side surface; and forming the substantially air impermeable layer on the two ePTFE tape side surfaces.

Preferably, the substantially air impermeable material is a melt processable fluoropolymer and the step of forming or bonding the at least one substantially air impermeable layer to the ePTFE tape comprises the steps of contacting at least one ePTFE side surface and the at least one substantially air impermeable material; applying pressure and heating the side surface of the porous ePTFE tape and the at least one substantially air impermeable material

above the melt temperature of the porous ePTFE and the at least one material to weld the heated material and the porous ePTFE together. Sufficient pressure is applied to bond the ePTFE tape side surface and the material, forming a substantially air impermeable layer on the side surface of the tape. Each of the steps of forming a substantially air impermeable layer on at least one ePTFE tape side surface, including the steps of 1) contacting the ePTFE tape side surface and the at least one material capable of forming a substantially air impermeable layer, and 2) applying heat and 3) pressure to the materials, may be performed simultaneously or sequentially. Further, a substantially air impermeable layer may be formed on at least one ePTFE tape side surface as a step-wise process for a portion of a tape length, or as a continuous process along the entire desired length of the tape.

A release layer may be provided between the material capable of forming the air impermeable layer and the pressure and/or heat source to prevent sticking. The substantially air impermeable material is bonded to a desired length of the porous ePTFE tape, which is preferably the entire tape length used to form a gasket. Fig. 6 illustrates a portion of a hot press assembly and a method for welding a substantially air impermeable layer on to the side surface of an ePTFE tape.

Alternately, the material capable of forming a substantially air impermeable layer may, for example, be coated onto the side surface of an ePTFE tape along the length of at least one tape. Coating may be accomplished by any means, such as spraying, brushing, or powder coating.

Preferred methods of forming a gasket comprising alternate windings of at least one porous ePTFE tape and at least one substantially air impermeable layer preferably comprises the steps of providing a length of porous ePTFE tape having a substantially air impermeable material layer along the length of the tape; winding the ePTFE tape around a form or a die; applying heat at a juncture of two sequential ePTFE tape windings, contacting and applying pressure and joining sequential windings until the desired width of the gasket is formed. Fig.7 illustrates a portion of a fixture for winding and welding the at least one ePTFE tape and at least one substantially air impermeable layer to form a gasket. Preferably, where the substantially air impermeable layer is applied to

both side surfaces of at least one porous ePTFE tape, the heating step comprises applying heat at a juncture of two substantially air impermeable layers of sequential ePTFE windings, above the melt temperature of the substantially air impermeable layer. The method further comprises applying pressure to weld the two substantially air impermeable layers together to join the sequential ePTFE windings.

The preferred steps of forming the gasket including the steps of 1) winding at least one ePTFE tape around a die, 2) applying heat at a juncture of the windings of the at least one ePTFE tape side surfaces having the substantially air impermeable layer bonded thereto, and 2) contacting and 3) applying pressure to the heated ePTFE side surfaces to weld the ePTFE windings, may be performed simultaneously, or sequentially. Further, the steps of forming the gasket may be performed step-wise or as a continuous process until the desired geometry of the gasket is formed.

In another embodiment, the steps of forming a substantially air impermeable layer on ePTFE side surfaces and the steps of winding the ePTFE tape and joining the ePTFE windings are combined in one continuous process.

Gaskets and methods of forming the materials of the present invention are exemplified, but not limited, by the examples presented below.

EXAMPLES

Example 1

An ePTFE/PFA coil gasket of the present invention was produced in the following manner.

A length of approximately 6 meters (20 feet) of Gore-Tex® Series 600 Gasket Tape (ePTFE tape) having a nominal width of approximately 10 mm (0.39 inches) and a nominal thickness of approximately 6 mm (0.23 inches) was obtained from W.L. Gore & Associates, Inc. of Newark, DE. A Teflon® PFA Film, Type LP having a width of approximately 13 mm (0.5 inches) and a thickness of approximately 0.025 mm (0.001 inches) was obtained from E.I. du Pont dė Nemours, Inc. of Wilmington, Delaware.

The PFA film was welded to the two side surfaces of the ePTFE tape along the entire length of the ePTFE tape. The PFA film was welded to the first side surface of the ePTFE tape using a hot press substantially similar to the press illustrated in Fig. 6 with upper press platen 61 heated to about 375°C and the

lower press platen 62 kept at ambient temperature. The upper and lower press platens 61 and 62 had a length of approximately 200 mm (8 inches). Therefore, 200 mm sections of the ePTFE tape were coated at a time. The ePTFE tape 63 was placed in a channel 64 in the lower platen with the side surface 66 of the ePTFE tape extending approximately 0.25 mm to 0.5 mm above the top surface of the lower platen 62. The PFA film 65 was placed on the side surface of the ePTFE tape and centered. Kapton® polyimide film 68 was obtained from E.I. du Pont de Nemours, Inc. of Wilmington, Delaware. A piece of the Kapton® film 68 was placed on top of the PFA film 65 as a release layer to prevent the PFA from sticking to the heated upper platen 61. The upper platen 61 was lowered with sufficient pressure being applied so that the upper platen 61 was in contact with the lower platen 62. The upper platen 61 was held in place for approximately five seconds and then lifted from the lower platen 62 . The Kapton® film 68 was removed from the formed ePTFE/PFA composite tape. The ePTFE/PFA composite tape was removed from the channel in the lower platen and the next 200 mm section of the ePTFE tape was inserted and the lamination process was repeated. After the entire length of the ePTFE tape was coated on the one side surface with the PFA film, the excess PFA film was trimmed from the ePTFE/PFA composite tape using a razor blade. The opposite side surface of the ePTFE tape was coated with the PFA film following the same procedures as above. The excess PFA film was trimmed from the ePTFE/PFA composite tape using a razor blade.

An assembly for making a gasket is illustrated in Figs. 7a and 7b. A circular die 71 was provided to a drive shaft 72, the die 71 having a diameter of about 203 mm (8 inches[) and a slot 73 for receiving an end of a tape. One end 74 of the ePTFE/PFA composite tape 75 was secured in the die 71 by placing the end of the tape in the slot and tightening set screws 77. One of the PFA coated side surfaces 76 of the composite tape was in contact with the edge of the die corresponding to the circumference. The die was rotated through one revolution creating the first winding 78 around the circumference of the die. A lower tape guide 79 was positioned to apply pressure in the direction indicated by the arrows of Fig. 7b to the tape via the air cylinder 80. The air cylinder pressure was set to 8 psig (55 kPa). A Leister Hot Jet S hot air gun 81 (Leister Process Technologies, Sarnen, Switzerland was positioned so that the tip of the nozzle was located approximately 6 mm from the juncture 82 of the ePTFE tape windings. The hot air gun was set to a temperature setting of 6 (maximum) corresponding to a rated temperature of about 600°C and air flow setting of 4 (maximum) corresponding to a rated air flow of about 80 liters/min. The die

rotational speed was set to approximately 0.25 rpm [using the speed control potentiometer on the drive system (Rapid-Air, Rockford, IL).] The PFA of each side surface was melted by the hot air 82 and the side surfaces of adjacent ePTFE tape windings 75 and 78 each having melted PFA were contacted to bond the tape side surfaces. The coiling process continued until approximately six windings 78 had been wound around the die. The lower tape guide 79 was lowered and the die and coiled composite gasket were removed from the drive shaft.

The coiled gasket having alternating winding of porous ePTFE and air impermeable PFA was formed and trimmed to final inner and outer diameter dimensions of about 220 mm (8.66 inches) and about 273 mm (10.75 inches), respectively, using a LMI Laser Cutter. The gasket had a final thickness of about 6.6 mm (0.26 inches) and a mass of approximately 131 g. The composite gasket made according to this example was tested for sealability in accordance with the procedures of the Sealability Test described herein. The results can be seen in Fig. 8.

Example 2

An ePTFE/PFA composite coil gasket of the present invention was produced substantially according to the procedures described in Example 1.

The gasket was trimmed to final inner and outer diameter dimensions of about 220 mm (8.66 inches) and about 273 mm (10.75 inches). The gasket had a final thickness of about 6.9 mm (0.27 inches) and a mass of approximately 138 g. The composite gasket made according to this example was tested for sealability in accordance with the procedures of the Sealability Test described herein. The results can be seen in Fig. 8.

Example 3

An ePTFE/PFA composite coil gasket of the present invention was produced substantially according to the procedures described in Example 1.

The gasket was trimmed to final inner and outer diameter dimensions of about 220 mm (8.66 inches) and about 273 mm (10.75 inches). The gasket had a final thickness of about 6.6 mm (0.26 inches) and a mass of approximately 106 g. The composite gasket made according to this example was tested for sealability in accordance with the procedures of the Sealability Test described herein. The results can be seen in Fig. 8.

Comparative Example 4

A GORE-TEX GR® sheet gasketing gasket having an inner diameter of approximately 220 mm (8.66 inches), an outer diameter of approximately 273 mm (10.75 inches), a thickness of 5.8 mm (0.23 inches), and a mass of 76 g was obtained from W.L. Gore & Associates, Inc. of Newark, Delaware.

The gasket according to this example was tested for sealability in accordance with the procedures of the Sealability Test described herein. The results can be seen in Fig. 8.

Example 5

An ePTFE/FEP composite coil gasket of the present invention was produced substantially according to the procedures described in Example 1 with the following exceptions. The initial width of the ePTFE tape was approximately 20 mm (0.79 inches). A 13 mm wide FEP film was obtained from E.I. du Pont de Nemours, Inc. of Wilmington, Delaware and bonded to the two side surfaces of the ePTFE in accordance with the procedures described in Example 1 for forming the composite tape. The excess FEP was trimmed from the tape using a razor blade. The diameter of the die used was about 430 mm (17 inches). The die rotational speed was set to about 0.1 revolutions per minute. Approximately five windings of the composite tape were coiled around the die and bonded using the hot air gun settings as in Example 1. A gasket having alternating rotations of ePTFE and air impermeable FEP was formed, and trimmed to final inner and outer diameters of about 435 mm and 537 mm, respectively, using a general purpose gasket cutter.

The gasket had a final thickness of about 6 mm (0.25 inches). The gasket was tested for leakage in accordance with the procedures of the Leakage Test described herein. The results can be found in Table 1.

Table 1: Leakage Test Results

	Leakage Measurements (mg/m/s)		
Sample ID	**1**	**2**	**3**
Example 5	0.0121	-	0.0086
Comparative Example 6	2.41	-	1.25

Comparative Example 6

A sample of GORE-TEX® Series 600 Gasket Tape as represented by Fig. 5 was obtained from W.L. Gore & Associates, Inc. of Newark, DE having a nominal thickness of 6 mm and a nominal width of 55 mm and length of approximately 1800 mm. A double-sided pressure sensitive adhesive having a width of about 25 mm was applied to one surface of the tape along the length of the tape and centered between the two edges. The pressure sensitive adhesive was a styrene butadiene rubber (SBR) based adhesive with a polyester carrier film and with a release paper on one side.

The tape was formed into a gasket as illustrated in Figs. 4a and 4b, with the longitudinal ends 42 joined by a skive cut 43. The gasket was tested for leakage in accordance with the procedures of the Leakage Test described herein. The results can be found in Table 1.

TEST METHODS AND PROCEDURES

Sealability Test Procedures

The sealability of gaskets made substantially according to Examples 1-3 and Comparative Example 4 was determined by measuring leak rates using a computer controlled, hydraulically driven test fixture, as seen in Fig. 9. Gaskets 91were installed in the test fixture on the lower platen 92. The gasket samples were compressed by hydraulic press 98 between the upper 93 and lower 92 platens to a stress of about 6 MPa. The internal pressure in the high pressure zone 94 was increased to about 27 bar using nitrogen gas as supplied by the compressed air bottle 97 as the test fluid. The internal pressure was maintained in the high pressure zone throughout the test period. As the nitrogen gas leaked past the gasket sample, the pressure in the low pressure zone 95 increased. The change in pressure in the low pressure zone was monitored by the pressure differential switch 96. The leak rate was calculated by the test fixture's software program based on the change in pressure in the low-pressure zone after a 90 minute (5400 second) dwell time and based on the following equation:

$$LR = (\rho_{nitrogen} \text{ x } V_o \text{ x } \Delta P)/(d \text{ x } \Pi \text{ x } \Delta t \text{ x } p_{atm})$$

where:

LR = leak rate (mg/m x sec)

$\rho_{nitrogen}$ = density of nitrogen at ambient conditions (mg/cm^3)

V_o = volume within test flange (cm^3)

d = average gasket diameter (m, meters)

d = (outer diameter + inner diameter)/2

ΔP = change in internal pressure in the low pressure zone = $P_o - Pf$

P_o = initial internal pressure at $t = 0$ seconds (bar)

P_f = final pressure at $t = \Delta t$ (bar)

Δt = test time (seconds)

p_{atm} = atmospheric pressure (bar)

The leak rates for each example tested can be seen in Fig. 8. The graph shows that all of the inventive examples tested, Examples 1 through 3, had significantly lower leak rates than the comparative example. A decrease in leak rate of at least about 1.5 orders of magnitude was realized with the inventive examples having substantially air impermeable layers as compared with Comparative Example 4 which is an ePTFE gasket without any impermeable layers interposed therein. The lower leak rate demonstrated by the inventive examples is attributable in part to the incorporation of the substantially air impermeable layer(s) oriented substantially perpendicular to the sealing surfaces in the gasket, and further, to the substantially parallel orientation of the plane of expansion of the expanded PTFE with the flange surface.

Leakage Test Procedures: Glass Lined Steel Test Fixture

The leakage behavior of gaskets made substantially according to Examples 5 and Comparative Example 6 were tested on an actual glass lined steel flange through a thermal cycle. The inner and outer diameters of the glass lined steel flanges were approximately 430 mm and 520 mm, respectively. Test gaskets were installed on the lower flange. The ePTFE tape in Comparative Example 6 was installed using the skive cut overlapping technique taught in U.S. Patent No. 5,964,465 to Mills et al. The first end of the tape samples were skive cut on a diagonal with a skive length of about 50 mm. The release paper was removed from the adhesive on the tape samples. The adhesive layer held the tapes in position as the tape was being formed around the lower flange. The trailing end of the tape was positioned on top of the skive cut on the leading end of the tape. The second skive cut was made on the trailing end of the tape so that a smooth transition was created at the overlap of the leading and trailing ends of the tape. The upper flange was positioned on top of the gasket and aligned with the lower flange. The flanges were bolted together using twelve M24 clamps. The clamps were tightened to a torque of 111 N-m generating a line force load on the gasket of approximately 200N/mm. The line force is equal to the total

force on the gasket supplied by the tightening of the clamps divided by the average circumference of the gasket. The average circumference is determined by multiplying the average diameter of the gasket [(gasket outside diameter + gasket inside diameter)/2] by pi. Ten minutes after the initial torque, the clamps were retightened to 111 N-m. The internal pressure was then increased to 6 bar using compressed air. After a 24 hour dwell under pressure at ambient temperature, the first leakage measurement was recorded. The fixture was then loaded in to an oven and re-pressurized to 6 bar with compressed air. The temperature of the oven was set to 200°C for a period of 16 hours. After cooling to room temperature, the second leakage measurement was recorded. The clamps were then retightened to 111 N-m to reestablish the 200 N/mm line force on the gasket. The fixture was re-pressurized to 6 bar with compressed air. The third and final leakage measurement was then taken. The leak rates were determined based on the change in internal pressure in the test fixture as measured by a differential pressure switch according to the following equation:

$$LR = (\rho air \times V_o \times \Delta P)/(d \times \Pi \times \Delta t \times p_{atm})$$

where:

LR = leak rate (mg/m x sec)

ρ_{air}= density of air at ambient conditions (mg/cm^3)

V_o = volume within test flange (cm^3)

d = average gasket diameter (m, meters)

d = (outer diameter + inner diameter)/2

ΔP = change in internal pressure = $P_o - Pf$

P_o = initial internal pressure at $t = 0$ seconds (bar)

P_f= final pressure at $t = \Delta t$ (bar)

Δt = test time (seconds)

p_{atm} = atmospheric pressure (bar)

The leak rates measured for each example can be seen in Table 1. The results in Table 1 show that after the 24 hour dwell at room temperature the inventive example (Example 5) had significantly lower leak rate as compared with Comparative Example 6. After the 16 hour dwell at 200°C, all of the gaskets experienced gross leakage (pressure change too large to be measured by the differential pressure switch). After the re-tightening of the clamps back to the 111 N-m torque, the inventive example again had significantly less leakage than the comparative example.

Wide-Angle X-ray Scattering Measurements

The plane of expansion of a multiaxially expanded PTFE gasket tape material was verified with wide-angle X-ray scattering measurements.

Samples of gasket tape material were cut from a length of GORE-TEX® Series 300 Gasket Tape with a nominal thickness of 3 mm. The GORE-TEX® Series 300 Gasket Tape material is comprised of multiple layers of a biaxially expanded PTFE membrane laminated together in the thickness direction. The ePTFE membrane layers are expanded in the longitudinal (x-direction) and transverse (y-direction) directions with the thickness oriented with the z-direction. Therefore, the plane of expansion is the x-y plane of the membrane and the Gasket Tape.

As illustrated in Fig. 10 test samples were cut parallel to the x-y plane 180, y-z plane 181 and the x-z plane 182 from the GORE-TEX Series 300 Gasket Tape. Four rectangular samples were cut using an LMI Laser Cutter from each planar orientation to approximately 3 mm by 15 mm by 0.5 mm. For the samples cut from the x-y plane 180, membrane layers were removed from a section of the nominally 3 mm thick tape to produce a tape section with a nominal thickness of 0.5 mm. From this 0.5 mm thick section, the rectangular test samples were cut to a width and length of about 3 mm and 15 mm, respectively, with the sample width parallel to the Gasket Tape width (y-direction) and the sample length parallel to the Gasket Tape length (x-direction). In these samples, the plane defined by the sample length and width (x-y plane) is parallel to the membrane layers and the plane of expansion of the ePTFE.

For the test samples cut in the x-z plane 182, two parallel cuts, approximately 0.5 mm apart, were made in the x-direction of the 3 mm thick Gasket Tape material. From this 0.5 mm wide and 3 mm thick section the 15 mm long test samples were cut. For these samples, the 3 mm by 15 mm area defined the x-z plane.

For the test samples cut in the y-z plane 181, two parallel cuts, approximately 0.5 mm apart, were made in the y-direction of the 3 mm thick Gasket Tape material. From this 0.5 mm wide and 3 mm thick section the 15

mm long test samples were cut. For these samples, the 3 mm by 15 mm area defined the y-z plane.

All measurements were made in transmission mode using a Rigaku R-Axis IV Image Plate X-ray Analyzer mounted on a Rigaku Ultra 18 kW rotating anode x-ray generator with a graphite monochromator and a 0.3mm pinhole collimator. Operating conditions on the generator for all experiments were 50kV and 200mA. Radiation type was Cu K_{α}. Sample-to-detector distance was set at approximately 120 mm, and calibrated using a silicon powder standard. All measurements were made on a temperature-controlled stage maintained at approximately 24±1°C. Two-dimensional image data was processed using Rigaku R-Axis image processing software to obtain I vs. 2θ scans. The scans were collected by radial integration over the angular range from $2\theta \sim 0°$ to $2\theta \sim 55°$ in increments of $\Delta 2\theta = 0.044°$.

The I vs. 2θ scans were processed using Jade 6.1 XRD Pattern Processing & Identification software purchased from Materials Data, Inc. The data processing procedure was as follows. Scans and associated air scattering background files were read into the software and scaled to match maximum intensity counts in the range of $2\theta=6°-8°$. The air scattering file was then used to define the scattering background and subtracted from the I vs. 2θ scans obtained from the samples. Finally, the position and intensity of the primary scattering peaks were identified using the software's standard peak search routine. It should be noted that the data was originally collected in two-dimensional form, and was analyzed without any correction into a form that would be directly analogous to data collected with a linear detector.

A typical I vs. 2θ diffraction scan is shown in Fig. 11. All scans show the characteristic diffraction peaks of polytetrafluoroethylene. The strongest peak, occurring near $2\theta=18.1°$, is attributable to the {100} crystalline planes. The next most intense diffraction peaks occur near $2\theta=37.1°$ and $2\theta=41.4°$, and are attributed to the {107} and {108} crystalline planes, respectively (see Eduard S. Clark, "Unit Cell Information on Some Important Polymers, " Chapter 30, Physical Properties of Polymers Handbook, James E. Mark, Ed. New York,: American Institute of Physics, 1996).

The GORE-TEX® Series 300 Gasket Tape material is comprised of multiple layers of a biaxially expanded PTFE membrane laminated together in the thickness direction. Orientation, or texture, is developed in the PTFE within the membrane during expansion that is retained within the Gasket Tape. Due to this texture, the relative intensity of the {100} and {108} peaks in diffraction scans obtained from the samples of the Gasket Tape is a function of the physical orientation of the sample relative to the thickness direction of the Gasket Tape.

When Gasket Tape samples are measured with the x-ray beam incident on the sample face in a direction that is perpendicular to the plane of expansion (x-y plane), the intensity of the {108} peak relative to the intensity of {100} peak is higher than for samples measured in other orientations. For example, in the case where the samples were cut parallel to x-y plane and measured with the x-ray beam perpendicular to the x-y plane (parallel to the z direction), the I vs. 2θ diffraction scans show higher relative {108} peak intensities than scans from samples cut in the x-z and y-z planes and measured with the x-ray beam perpendicular to those faces (parallel to the y direction, and parallel to the x direction, respectively). This is illustrated in Table 2, in which data are presented from the analysis of I vs. 2θ diffraction scans for twelve (12) samples, four (4) cut from three (3) different orientations relative to the thickness direction of the Gasket Tape. In Table 3, the relative {108} peak intensity is reported as a percentage of the {100} peak intensity, to normalize for sample-to-sample variation in thickness, density, or measurement time. As illustrated in Fig, 10 and noted in Table 2, samples with x-z orientation were measured such that the x-ray beam was incident on the x-z face in a direction parallel to the y-direction. Similarly, samples with y-z orientation were measured such that the x-ray beam was incident on the y-z face in a direction parallel to the x-direction, and samples with x-y orientation were measured such that the x-ray beam was incident on the x-y face in a direction parallel to the z direction. Samples were cut and positioned such that the x-ray beam was incident on the 3 mm by 15 mm face.

Table 2.

Sample	Plane	Beam Direction	{108} Peak Intensity (% of {100} Peak)
1	x-y	parallel to *z*	35.7
4	x-y	parallel to *z*	32.5
7	x-y	parallel to *z*	32.9
12	x-y	parallel to *z*	33.3
2	y-z	parallel to *x*	6.2
6	y-z	parallel to *x*	6.5
9	y-z	parallel to *x*	6.1
10	y-z	parallel to *x*	5.7
3	x-z	parallel to *y*	13.5
5	x-z	parallel to *y*	12.2
8	x-z	parallel to *y*	12.1
11	x-z	parallel to *y*	13.2

In Table 2, the {108} relative peak intensity, expressed as a percentage of the corresponding {100} peak intensity within a single I vs. 2θ x-ray scan, is given for the variety of gasket sections. Samples 1, 4, 7, and 12 which were measured in the x-y orientation with the x-ray beam parallel to the z direction have significantly higher relative {108} diffraction intensities than the samples measured in the x-z orientation or in the y-z orientation with the x-ray beam directed as stated above. Thus, the highest {108} relative peak intensity is measured for samples positioned such that the x-ray beam is incident on the sample in a direction l perpendicular to the plane of expansion of the biaxially expanded PTFE membrane layers. Therefore, comparison of {108} relative peak intensities in different orientations can be used to identify the plane of expansion of ePTFE in a Gasket Tape.